PB-250 548

RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 10 TON/HR AND OVER, HARD-COAL FIRED WITH MECHANICAL GRATES

Public Health Service

Prepared for:

Environmental Protection Agency

November 1961

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

079018

PB 250 548

VDI-RICHTLINIEN November 1961

VEREIN DEUTSCHER INGENIEURE	Staubauswurfbegrenzung Dampfkessel uber 10 t/h Leistung Steinkohlenfeuerungen mit Unterwind-Zonenwanderrost	VDI 2091

APTD-1584

RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 10 TON/HR AND OVER, HARD-COAL FIRED WITH MECHANICAL GRATES

This publication, translated from the German, was prepared by the Association of Steam Boiler Owners, Essen, in collaboration with the Technical Inspection Services, Essen. All rights reserved.

Reproduced with permission by the
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Washington, D. C.

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

VDI-Kommission Reinhaltung der Luft

VDI-Handbuch Reinhaltung der Luft

BIBLIOGRAPHIC DATA SHEET	1. Report No. APTD-1584	2.	3. Recipient's Accession No. PB250548

4. Title and Subtitle
Restricting Dust Emission from Forced-Draft Boiler Installations, Capacity 10 Ton/Hr and Over, Hard-Coal Fired with Mechanical Grates

5. Report Date
November 1961

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Verein Deutscher Ingenieure
Kommission Reinhaltung der Luft
Germany

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U. S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C.

13. Type of Report & Period Covered

14.

15. Supplementary Notes
Trans. of VDI-RICHTLINIEN 2091

16. Abstracts
The purposes of these specifications are to describe the parts of the installation in which dust occurs; to characterize the influences leading to the formation of dust; to point out measures for the selection of suitable dust-removal installations and their maintenance; and to establish guidelines for the restriction of dust emission by new installations. Stacks are considered as means to minimize the ground level concentration of particulates.

17. Key Words and Document Analysis. 17a. Descriptors
Air pollution
Air pollution control equipment
Boilers
Combustion gases
Dust
Coal
Chimneys
Electrostatic precipitators
Atmospheric diffusion

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 13B

i

PRICES SUBJECT TO CHANGE

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 30
Unlimited	20. Security Class (This Page UNCLASSIFIED	22. Price $4.00 -2.25

Foreword

This is one of several dozen VDI Clean Air Committee specifications on air purification which the Division of Air Pollution of the U.S. Public Health Service has obtained permission to translate, publish, and distribute in limited quantity. A complete list of the VDI publications being published by the Division of Air Pollution appears on the inside back cover. Because the VDI Committee from time to time revises these specifications, this and other publications in the series may be superseded by later publications.

The VDI Clean Air Committee specifications are compiled by trade or professional associations and published by the Committee. The Committee has neither official status nor regulatory authority, although West German governmental agencies participate in its activities. Air quality specifications published by the Committee are therefore advisory, rather than regulatory. They may however later be adopted by West German governmental authorities.

The English translations were done by the Joint Publications Research Service of the Office of Technical Services, U.S. Department of Commerce. It should be borne in mind that various terms literally taken from the German do not have the same connotation in English; for example, the word "standard" frequently appears where the word "criteria" might better reflect the comparable American meaning, since in this country "standard" is generally meant to imply a legally enforceable value, while "criteria" usually means a recommended value upon which standards may be based.

The publication and distribution of these translations by the Public Health Service constitutes neither endorsement of the specifications nor of the air quality or emission limitations recommended in them. We believe that they contain much useful information that would otherwise not be available to non-readers of German and for this reason have made them available to workers in the air pollution field in the United States.

RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 10 TON/HR AND OVER, HARD-COAL FIRED WITH MECHANICAL GRATES

Prepared by:

Association of Steam Boiler Owners, Essen
in collaboration with
Technical Inspection Services. Essen.

VDI No. 2091, November 1961

TABLE OF CONTENTS

		Page
	VDI Committee for Air Purification	iii
	Introduction	1
1.	Technology	2
	Guide Values for Standard Furnace Installations: . . .	2
2.	Reduction of Dust Emission	5
2.1	Influences within Steam Generators	5
2.2	Dust Removal at Dust-Removal Installations	7
2.21	Efficiency Rates	9
2.22	Influence on Efficiency Rate of Separators	11
2.221	Mechanical Dust Separators	11
2.222	Electrostatic Precipitators	12
2.3	Stacks	14
3.	Restriction of Dust Emission	14
3.1	Restriction of Emission on the Basis of Deposition . .	15
3.2	Restriction of Emission on the Basis of Technical Factors	15
3.21	Instructions for Utilization of Diagram	16
	References	21

VDI COMMITTEE FOR AIR PURIFICATION

The VDI Committee for Air Purification is composed of experts in all fields of importance for air purification. These experts collaborate with the Committee on their own responsibility and without compensation and are proposed for the Committee by the following societies and institutions:

German Society for Hygiene and Microbiology
German Society for Oil and Coal Chemistry
German Society of Gas and Water Experts
German Meteorological Services
Society of German Chemists
Society of German Iron Mine and Steel Mill Experts
Association of Anthracite Mines
Technical Inspection Associations
Society of German Steel Mill Experts
Society of German Foundry Experts
VDI Trade Section on Dust Technology
Association of Steam Boiler Owners

Scientists from Universities and Institutes in Biology, Chemistry, Forestry and Agriculture, Human and Veterinary Medicine, Metallurgy, Physics, and Technology
Research Institute of the Cement Industry

Federation of German Industry (Chemical Industry, Oil Industry, Automobile Industry, etc.)
German Federal Railroads
Federation of German Farmers
Federation of Community Associations
Settlement Federation of the Ruhr-Coal District
Competent Federal and State Ministries
Institute for Water, Soil, and Air Hygiene of the Federal Public Health Service
Public Inspection Services

INTRODUCTION

The VDI Specifications on Air Purification are divided into the following groups:

1. Permissible Immission Concentration (PIC-values)
2. Calculation of the Distribution of Dust and Gas
3. Restriction of the Emission of Dust and Gas
4. Dust and Gas Measuring Techniques.

In the evaluation of problems of air pollution, the inner relation of these four groups of specifications must be considered.

The present specifications concern the occurrence and reduction of dust in steam-generating installations with a capacity of 10 ton/hr and over.

It is the purpose of the specifications:

To describe the parts of the installation in which dust occurs;
To characterize the influences leading to the formation of dust;
To point out measures for the selection of suitable dust-removal installations and their maintenance;
To establish guide lines for the restriction of dust emission by new installations.

The measures recommended in the specifications take into account the most recent technical findings. As the latter are further developed, the specifications will be adapted to them.

VDI Specifications No. 2299 (in preparation) is applicable to the restriction of the emission of gas, including sulphur dioxide, by steam generating installations.

1. Technology

Guide Values for Standard Furnace Installations:

In any furnace installation, fly-ash occurs which consists of fly-ash and unburnt particles. The grain size of fly-ash from furnace grates is generally relatively coarse and the share below 10 μ so low that normally dust removal by centrifugal separators is adequate. The share of unburnt particles may be very high. The dust content of the flue gases ahead of the dust separator (raw-gas dust content) increases with the load and with the intensity of the forced and/or natural draft. The largest part of the ash introduced into the furnace becomes fused on the grate and is discharged from the mechanical grate as clinker (fusion). Part of the coarse fly-ash is deposited in the boiler flues. The size of the first dust-removal installation and/or the efficiency rate selected is influenced by the rate of fusion of the ash in the furnace and in the boiler flues (2).

Given suitable design and proper operation of the furnace installation, black smoke (soot) should not occur (Cf. VDI Specifications No. 2300 on Restricting Dust Emission from Steam Generators, capacity 10 ton/hr and less; in preparation).

The following indicates average values but individual steam generators have been built for capacities and conditions which differ essentially from the data below.

Table 1

Utilisation of Forced-Draft Mechanical Grates	Steam Generators, Capacity 10-100 ton/hr
Fuel range	
Coal type	From lean to caking gas coal.
Grain classification	Nut I-V, generally II-IV; breeze with a maximum share of < 1 mm of 30%
Volatile components (in relation to water- and ash-free coal).	8-40%, generally 10-30%.
Ash content (in relation to water-free coal; 2, 3).	Up to 30%, generally 5-15% (high values for rich coal).
Sulphur content	1.0 - 1.5%
Water content	5 - 15%, generally 5 - 8%.
Calorific value	7,500-4,200 kcal/kg
Grate-surface loading (4)	100-150 kg/m^2/hr
Excess air (4).	About 10% of combustion air; pressure 250-800 mm water
Preheating of air	Up to 150° C.
Flue Gases	
Temperature	130 - 250° C
CO_2 - content	12 - 11%
Specific volume (average values; 5)	At calorific values of 7,500 5,000 4,200, respectively 12.1 8.9 7.7 Nm^3/kg of coal
Dust content in raw gas (in relation to moist gas)	0.5 - 40 g/Nm^3, generally 0.5 - 10 g/Nm^3 (high values for lean fuels with high share of fine grains, with fly-ash recirculation, high grate loading and high content of incombustibles).
Grain classification of raw-gas dust.	Cf. Fig. 1.
SO_2 - content in raw gas	Cf. VDI Specifications No. 2299 (in preparation).
Ash fusion on grate and in flues (2).	75 - 85% of the total ash introduced with the fuel.

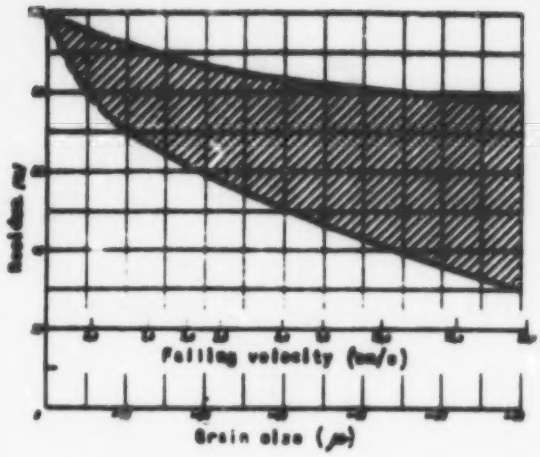


Figure 1. Classification Range of Dust in Raw Gas from Hard-Coal Furnaces (From the Investigations of the TÜV Essen: 1).

(Primary measurements are the falling velocity in air; the grain sizes so calculated are valid only for spherical particles of the specific unit weights γ = 2 g/cm^3).

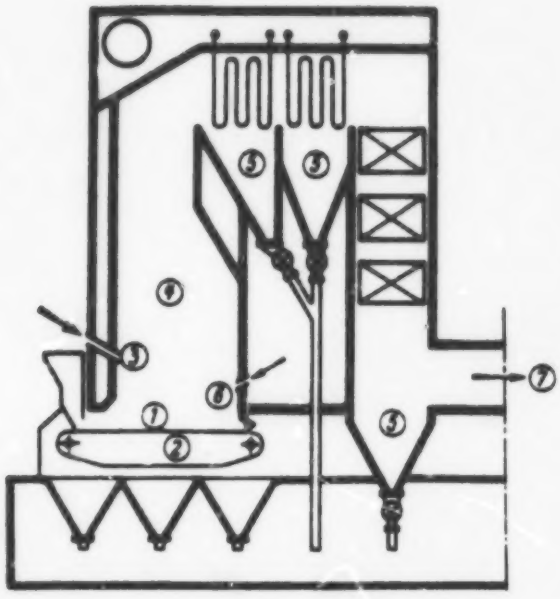


Figure 2. Diagram of Steam Generator with Forced Draft and Mechanical Grate.

Numbers designate points influencing formation of dust.

1 - Fuel bed; 2 - Admission of grate air with zone regulation; 3 - Secondary air admission; 4 - Combustion chamber with radiation heating surfaces; 5 - Dust collector below secondary heating surfaces; 6 - Fly-ash recirculation; 7 - Dust separator installation.

2. Reduction of Dust Emission

2.1 Influences within Steam Generators

Table 2

In regard to the formation of fly-ash, the conditions listed below act:

Point of Origin	Increasing	Reducing
Fuel bed, Fig. 2 ①	High ash content (medium classification, slurry); unfavorable ash characteristics (not fusing easily and fine-grained).	Adapting furnace firing, load and operation to high ash content and unfavorable ash characteristics.
	Too many fine grains, e.g. fine-grained and non-screened fuels; breeze with more than 30% of grains < 1 mm, coke breeze, quenched coal. Disregard of the necessary special measures when firing fine-grain fuels.	Screened coal, e.g. nut coal, screened breeze. Careful handling during conveying, storing and charging to reduce further crushing of coal. With breeze, possibly top layer of better grain size. Prevention of grain unmixing when charging fuel.
	Poor caking characteristics e.g. lean coal, coke breeze, quenched coal.	Caking coal, e.g., bituminous coal.
	Formation of ribbons and craters on grate. Turbulence above fuel bed.	Properly adjusted fuel charging, layer height and forced-draft pressure.
	Mechanical or manual stoking.	Reducing draft during stoking.
	Inappropriate construction of grate, e.g., grate too short, inadequately adjustable forced-draft zones, unsuitable grate covering, unfavorable slot width. Missing or improperly adjusted clinker arrestors.	Proper selection of special grates and grate covering for the combustion of unfavorable fuels. Low grate loading.

(continued)

(continuation)

Point of Origin	Increasing	Reducing
Forced Draft, Fig. 2 ②	High air velocities in fuel bed, high natural and forced draft, high grate-surface loading, overloading. Poor air distribution, high excess air and non-uniform grate covering.	Forced and natural draft corresponding to fuel classification and bed height. Adapting zone regulation to rate of combustion to prevent coal particles from being blown out of fuel bed.
Secondary air and fly ash recirculation, Fig. 2 ③ and ⑥	Incorrectly directed secondary air admission with high turbulence above fuel bed.	Correctly admitted secondary air (pyrotechnically and aerodynamically) at proper temperature for proper combustion of suspended fuel particles; distribution in many jets of high velocity. Prevention of turbulence in fuel bed.
	Unfavorably introduced fly-ash.	Adding recirculated fly-ash to fuel and possibly moistening it during charging of coal. When injected into the combustion chamber, testing for most favorable jet direction for best combustion.
	Formation of soot (possible with coal of high gas content).	Prevention of soot formation by proper distribution of primary and secondary air of adequate temperature; best distribution of air at adequately high temperature; best mixture of air with combustion gases.
Combustion chamber, Fig. 2 ④	Unfavorable flow condition of flue gases because of incorrectly constructed flues and/or excessive gas velocities. Excessive rising velocities, inadequate dimensions of combustion chamber, inadequate combustion intervals.	Aerodynamically correct construction of necessary ignition and recirculation flues (e.g. high and wide combustion chambers for coal with low gas content).

(continued)

(continuation)

Point of Origin	Increasing	Reducing
Secondary heating surfaces and fly-ash collector, Fig. 2 ⑤	Unfavorable flow conditions in boiler flues.	Correct air-flow design of boiler and smoke flues for best precipitation of fly-ash, aided by baffles, bends and changes of cross section.
	Unsuitable and leaking fly-ash collectors. When not properly sealed, already precipitated dust can be entrained.	Large fly-ash collectors with steeply inclined sliding surfaces. High-grade trap closure for discharge of fly-ash. (Under favorable conditions, 80-85% of fly ash remain in the clinker and in the fly ash collectors).
	Failure to empty fly-ash collectors at the proper time.	Properly scheduled discharge intervals and careful maintenance of discharge traps.
	Dust clouds due to activation of soot-blower and ball-rain installations.	Activation of fly-ash blowers and ball-rain installation preferably under light load
Dust separator, Fig. 2 ⑦	Cf. Section 2.21, 2.221, 2.222.	

2.2 Dust Removal at Dust-Removal Installations:

In general, only centrifugal (cyclone) separators or electrostatic precipitators are suitable for removal of dust from flue gases of steam-generating installations.

Cyclones have high efficiency rates only with coarse dust. Electrostatic precipitators are better for dust with a large share of grains below 10 μ (about 50% < 10 μ). On the other hand, electrostatic precipitators are more sensitive to overloading by high gas volumes and to dust with particularly high electrical resistance.

When the share of grains less than 10 μ is small, high-grade centrifugal separators are generally adequate for grate furnaces. In particularly unfavorable cases with a very high share of fine grains, an electrostatic precipitator may need to be added.

Under the present status of dust-removal technics, it should be possible to always attain guaranteed performance values -- except in rare cases -- when carefully planned. The measurement tolerances inherent in the measurement method employed should be taken into account.

The following factors influence the selection of the type of separator:

a) Type of construction and capacity of steam generator and furnace installation, installation with or without fly-ash recirculation, rate of ash fusion;

b) Characteristics of the fuel (volatile components, ash content, ash behavior);

c) Amount, grain classification and characteristics of raw-gas dust;

d) Available space for dust separator (6);

e) Stack height and discharge conditions (gas temperature and velocity);

f) Permissible emission.

Points a, b, c influence the volume and dust content of raw gas; point f depends among others on conditions in the vicinity, orographic and metereological factors, prior loads and on point e (Cf. Sec. 3).

The design of the dust separator and/or its over-all efficiency rate is not exclusively decisive for the rate of emission. In one and the same dust separator and/or at the same efficiency rate, emission from the stack will reach higher values when the raw-gas dust content increases. In large installations and with a high-ash content of the coal, it may therefore become difficult to reduce emission from the stack through selection of a high-grade separator to the desired degree whereas, at a low raw-gas dust content, adequately low emission may already be attained by utilization of a simple dust separator. The raw-gas dust content is especially influenced by the factors listed under points a and b. For the selection of the type of separator, the points a, b, c are therefore particularly important.

Measurement of dust content in raw and purified gas should be carried out according to VDI Specifications No. 2066 (7, 8) and suitable measurement distances and instruments taps should be provided already in the design of the installation, together with early agreement on the method of measurement of amount and of analysis of dust (blast sorting, sedimentation analysis, etc.). (14).

In order to prevent later discussion, it is recommended to settle already during the planning of new installations all questions important for dust removal from fuel gases between the future operators, suppliers and inspection services. This includes, in addition to an unmistakable wording of the agreement on the guaranteed rate of dust precipitation, also a clear understanding of the prerequisites on which the guaranty is based. The agreed guaranty must be metrologically demonstrable in each case (14).

The instructions of the supplier of the dust-remover installation must be observed. The separator must be properly controlled and maintained in operation (Cf. pointers in Section 2.22 and the "Specifications on Placing Orders for Dust Removal Installations" of the Association of Steam Boiler Owners in Essen; 14).

2.21 Efficiency Rates:

The following table contains efficiency rates obtained, under the present status of technology, from acceptance-inspection measurement of new installations.

In view of the inevitable drop in efficiency rate which experience shows to occur under operational conditions even with proper maintenance, the values listed in Table 3 can be valid only for the conditions on which the performance guaranty of a new installation is customarily based (absence of dirt, wear, etc.). The values of the table are therefore not applicable for the evaluation of dust emission in continuous operation (Cf. Sec. 3). The drop of the efficiency rate in operation as constrasted to the performance guaranty depends on structural and especially operational factors. It should be evaluated with great care during the planning of new installations in order to provide for an adequate interval of time between overhauls of the flue-gas purification installation in operation.

Table 3

Guaranteed Efficiency Rates of New Separators

The following values were obtained under favorable conditions, e.g. during inspection acceptance. The high values listed in the table will therefore not be attained in all cases. In special cases, installations have been constructed in which these values have been exceeded.

Type of Separator	Efficiency Rate * %	Draft required mm H_2O	Range of Utilization
Centrifugal (multi-cyclone)	Up to 95	50 - 100	Normal case; coarse-grain dust (for dust with low share of grains < 10 μ).
Centrifugal and electro-static	Up to 98.5	65 - 100	In special cases (for dust with very high share of fine grains < 10 μ).

* Depends largely on type of dust, content of dust, fineness of dust, shape of grain, gas and operational factors. The efficiency rate alone does not give any indication on the prevention of emission.

2.22 Influence on Efficiency Rate of Separators:

2.221 Mechanical Dust Separators:

Table 4

For operational efficiency, conditions listed below are:	
Unfavorable	Favorable
High share of fine grains in raw-gas dust (Cf. Fig. 1).	Design of separator adapted to given dust classification and characteristics.
Non-uniform loading of several parallel cyclones.	Uniform distribution of flue gases to several parallel aggregates and proper air-flow design of raw-gas ducts.
Inadequate adjustability of separator. When adjustable, incorrect adjustment of load.	Shut-down of one or more aggregates under partial load.
Internal leakage due to wear; bypasses between individual cyclone or separator cells.	Proper maintenance and frequent inspection of parts subject to wear and suitable lining when necessary.
Clogging of cells and dust-discharge traps of individual cyclone and separator cells. Leaking valves and traps, especially of dust-discharge devices.	Prevention of temperature drop below dew point. Continuous control of measurable operating data of separators, e.g. pressure drop and energy consumption (changes in values generally indicate defects and errors).
Wrong dimensions of separator (efficiency rate depends on flue-gas throughput).	Correct dimensions of separator for normal steam-generator load.

2.222 Electrostatic Precipitators:

Table 5

For operational efficiency, the conditions listed below are:	
Unfavorable	Favorable
Operational deviations from design data of separator, e.g. raw-gas volume and velocity (extraneous air, overloading), temperature, moisture, dust content, grain classification, and characteristics of dust.	Low gas velocity and adequate interval of passage through separator. Strict compliance with operating instructions.
Electrical resistance of dust too high or too low due to changes in fuel, ash or grinding, especially poor or especially good combustion, flue-gas too dry, unfavorable temperature and moisture. (Especially good combustion can result in excessive combustion chamber temperature, ash vaporization, high share of ultrafine particles and solid dust deposition on electrodes).	Favorable content of incombustibles (5-15%). Electrical resistance of dust around 10^4 and 10^{11} Ohm x cm, moist flue-gas (moistening of flue-gas when necessary).
Inappropriate voltage for given characteristics of raw gas and/or dust (frequent sparking, short circuits or switch opening). Unsuitable deposition and spray electrodes.	Maximum possible voltage through full-automatic regulation. Circuit of flue-gas flow most favorable for given type of dust and corresponding phasing of electrode voltage in the individual chambers (preionization when necessary). Adequately designed high-voltage aggregates.

(continued)

(continuation)

For operational efficiency, the conditions listed below are:	
Unfavorable	Favorable
Non-uniform gas and dust flow, aerodynamically unfavorable structural members in dust chamber (deposition of dust on girders, etc.). Non-uniform distribution of dust in flue-gas flow.	Uniform velocity and distribution of dust over the entire cross-section of electrofilter using baffles or perforated plates for improvement of flow when necessary. Prevention of dust accumulation in stagnant angles at baffles and electrodes.
Inappropriate vibration (e.g. simultaneous vibration of all plates, vibration intervals too long or too short), fouled deposition electrodes, (inactivation of electrical field and occurrence of clogging of entire ducts).	Proper operation and maintenance of filter cleaning devices (vibrators, beater devices, etc.) and careful inspection of electrodes, cleaning interior of separator during boiler shutdown, when necessary.
Non-uniform or inappropriate ash removal, admission of extraneous air during ash removal, leaking ash traps. Turbulence above already deposited dust.	Regular and/or automatic ash removal; well sealed ash-discharge devices and proper inspection and maintenance of the latter; prevention of admission of extraneous air (e.g. leaking valves of bypass ducts).
Poor inspection and maintenance of overall installation. Non-uniform distances of electrodes. Damage to insulators.	Systematic supervision of main aggregates and scheduled control of efficiency rate; scheduled overhaul, continuous control of measurable operating data (changes in values generally indicate defects and errors).

2.3 Stacks:

Determination of the necessary stack height and discharge cross section should be made by utilizing:

The indications in Sec. 3, Restriction of Dust Emission;

VDI Specifications No. 2299 (in preparation), Restriction of Sulphur-Dioxide Emission;

VDI Specifications No. 2289 (in preparation), Determination of Minimum Stack Height.

In addition to creating draft, an essential purpose of the stack is to discharge gas and dust as high as possible above the surface of the ground and to reduce the concentration of substances foreign-to-air above the ground and the deposition of dust on the ground by the resulting dilution of the gases with atmospheric air (9, 10, 11, 12).

This can be accomplished by:

High stacks;

Utilization of the thermic lift of the smoke streamer;

High discharge velocity of flue gas at the top of the stack.

At the same temperature and velocity of flue gas, greater thermic lift may be expected from one stack (with larger diameter) than by distributing the same volume of flue gas over several stacks of smaller diameter. For this reason, the discharge of the flue gases from several steam generators by one chimney with a large diameter may be more advantageous than several stacks with correspondingly smaller diameters. Any decision in regard to this must, however, take into account partial load factors.

3. Restriction of Dust Emission

All newly constructed steam-generating installations fired with ash-containing fuels must be equipped with dust-removal installations which should be designed -- unless Sec. 3.1 makes higher demands -- according to the conditions for restriction of emission in Sec. 3.2 and in the diagram "Restriction of Dust Emission in Newly Constructed Installations". All such dust-removal installations must correspond to the most recent technical findings (15, 16).

Reproduced from best available copy.

3.1 Restriction of Emission on the Basis of Deposition:

The emission of dust from an installation should be restricted on the basis of the permissible amounts of deposition in the vicinity and by the conditions of distribution given through the location and type of construction of the plant (stack height, adjacent emitters, orographic position, etc.). This should take into account already existing prior load factors and the permissible dust level of the area (the manner of determining the restriction of emission by deposition takes into account the natural laws of the relation between emission, distribution and deposition; Cf. VDI Specifications No. 2289 on Determination of Minimum Stack Height).

3.2 Restriction of Emission on the Basis of Technical Factors:

Unless the conditions in Sec. 3.1 make higher demands on the degree of purity of the flue gases, a technically and economically defensible installation corresponding to the type and capacity of the main installation should be provided for the reduction of dust content in flue gas.

In the diagram "Restriction of Dust Emission in Newly Constructed Installations", the maximum permissible dust emission from a new installation is represented as a function of the total amount of ash produced in the furnace installations of the overall installation. For the determination of the amount of ash produced by the overall installation, calculations should be based on maximum continuous output of the steam-generating installation. The permissible volume of dust emission for the new installation results from the percentage indicated in the ordinate as a function of the amount of ash produced in the new installation.

The limiting curve of the diagram for the maximum permissible dust emission in continuous operation is applicable to normal and technically controllable operating conditions. If special difficulties for the construction of the dust removal installations result from the type of fuel or conditions of combustion, minor increases of the permissible emission in continuous operation may be authorized after careful examination of all technical possibilities. For an ash total in excess of > 100 ton/hr, a special authorization should be procured in each case for maximum permissible emission. A transgression of the established maximum permissible emission values in operation can be accepted only in exceptional cases where subsequent operational factors could not be anticipated during planning and if the dust removal installation was designed according to the most recent technical findings.

3.21 Instructions for Utilization of Diagram:

The regulations on restriction do not indicate the degree of dust separation to be selected but the maximum permissible volume of dust emission (fly-ash including cinders). The decision on the degree of dust separation can be made in each case only in consideration of the dust deposition in the boiler (ash fusion) and the permissible dust emission (it is recommended to include future plans for enlargement in the calculations).

The letter symbols in the diagram and/or the examples below (13) represent:

A_{m_g} = (Abscissa) = the total ash from furnace installations of the overall installation in ton/hr at maximum continuous output of the boilers.

A_{m_n} = The total ash from the furnace installation of the new installation in ton/hr under maximum continuous output of the boiler.

(In the determination of the A_m-values, the maximum average 28-day value of the ash content of the fuel to be expected should be used.)

σ_s = (Ordinate) = maximum permissible dust emission from new installation in continuous operation as % of the total ash A_{m_n} of the new installation under maximum continuous output of the boiler.

β = Degree of ash fusion of the furnace installation.

An extrapolation of the limit curve for σ_s to the left or right beyond the range of the diagram should not be made. Special authorization should be procured for A_{m_g} = 100 ton/hr. For installations below A_{m_g} = 0.2 ton/hr, VDI Specifications No. 2300 "Restricting Dust Emission from Boiler Installations, Capacity 10 ton/hr and Less" is applicable.

The air pollution to be anticipated is decisively influenced by the dust emission from the overall installation. The diagram therefore contains as abscissa the total ash A_{m_g} of the overall installation. The overall installation consists of individual aggregates which are structurally related or may be considered as operational units. The overall installation may have one or more stacks.

The ordinate represents the stack discharge (σ_s) permissible for the new installation as % of the total ash from the new installation.

A new installation is considered to be a newly constructed installation either entirely new or an addition to an existing installation. If a new installation is constructed as an addition to an existing installation, then the existing installation together with the new installation is considered to be the overall installation.

The maximum permissible emission indicated in the diagram is valid for maximum continuous load in continuous operation during the authorized operating life of the installation. In connection with this, it should be recalled in particular that the effectiveness of dust separators drops after long-continued operation. In the determination of performance guarantees on the basis of the values for the restriction of emission, this should be taken into consideration accordingly (Cf. Sec. 2.21).

The lines in the diagram traced below an angle of 45° are guidelines for the minimum stack height to be employed. Stack height is here considered the height of the top of the stack above the ground.

The minimum stack height results from the intersection of the vertical of the respective A_{m_g}-value (abscissa) with the curve for the maximum permissible dust emission. Lesser stack heights require special measures for dust removal. Stack heights lying above the line for the maximum permissible dust emission, i.e., greater stack heights, do not authorize calculation of higher dust emission values than correspond to the curve for the maximum permissible dust emission.

In consideration of the immediate vicinity, however, the top of the stack should be at least 1.7 times as high as the highest building in the vicinity of the stack (11, 12).

Above the 120-m line, i.e., for very large installations, special authorization should be procurred for the minimum stack height.

Examples:

a) Existing Installation:

Steam production	150 ton/hr
a_f = 20% (in relation to delivery state)	
Total fuel	18.5 ton/hr
Total ash in fuel	3.7 ton/hr

b) New Installation:

Steam production	100 ton/hr
a_f = 20% (in relation to delivery state)	
Total fuel	12.35 ton/hr
Total ash in fuel A_{m_n}	2.47 ton/hr
Degree of ash fusion f = 75%	

c) Overall Installation:

Steam production	250 ton/hr
Total fuel	30.85 ton/hr
Ash total A_{m_g}	6.17 ton/hr

According to the diagram, this then results for the newly constructed part of the installation in A_{m_g} = 6.17 ton/hr according to the limit curve

$$\sigma_s = 4.65\%.$$

The required minimum stack height for A_{m_g} = 6.17 ton/hr (interpolated) amounts to H = 80 m.

This minimum height is sufficient only when a greater stack height is not required by Sec. 3.1 or in consideration of buildings in the vicinity (Cf. Sec. 3.21) or on the basis of the VDI Specifications on Sulphur-Dioxide Emission.

If unavoidable circumstances permit a stack height of only 70 m, dust emission may then only amount to σ_s = 2.95% (this reduction in stack height is obviously permissible also only if the condition listed in the previous paragraph has been fulfilled). Higher stacks than required by the diagram do not justify higher emission.

For installations without fly-ash recirculation, the required degree of dust separation ε can be determined from the following formula

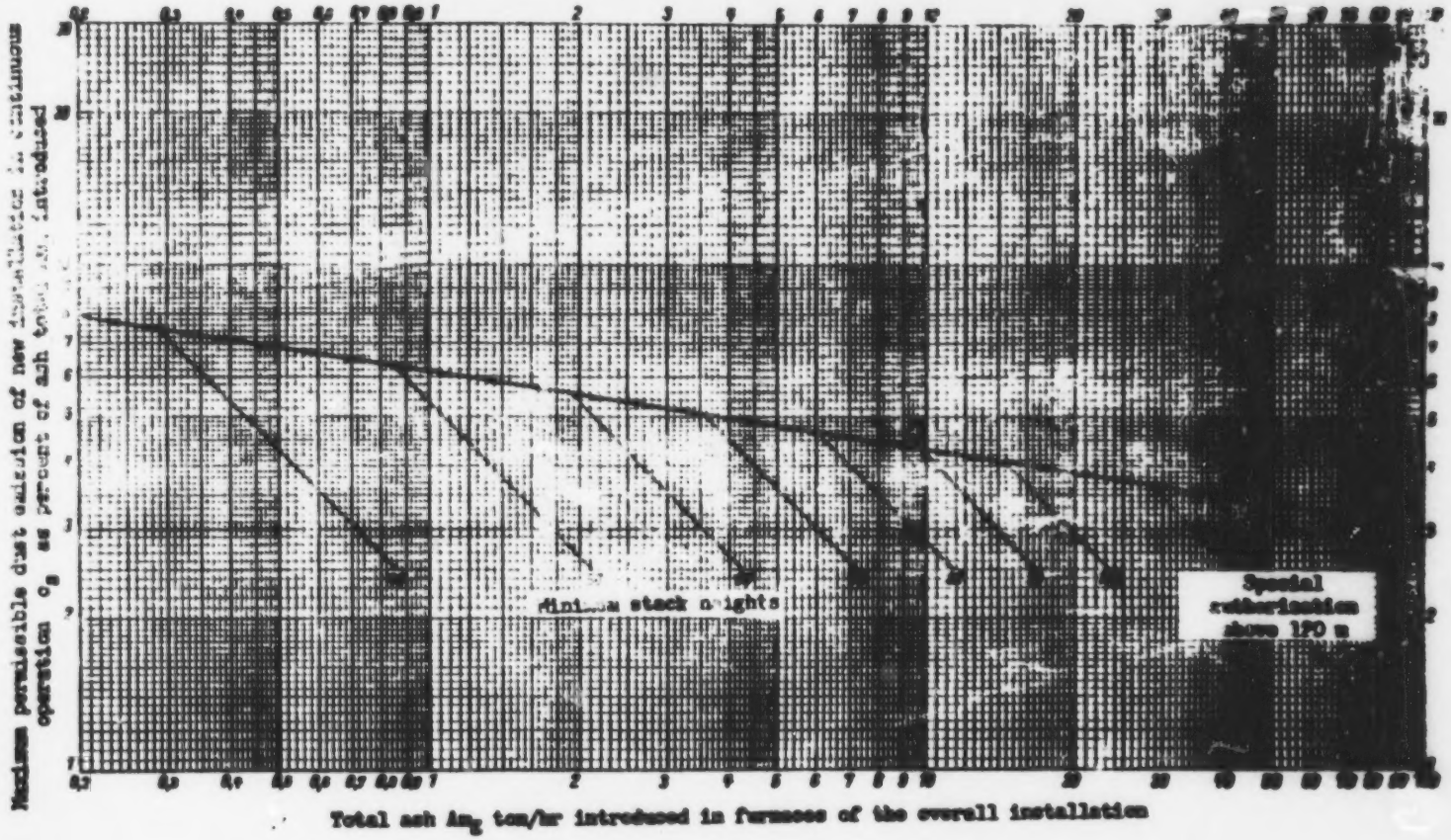
$$\varepsilon = 1 - \frac{\sigma_s}{1 - \beta} .$$

The values for σ_s determined from the above examples shall not be exceeded in continuous operation. The manner in which these emission values are obtained is left to the discretion of the designer of the steam-generating installation. He may make his selection among the possibilities which are offered to him by the design of the

steam generator and of the furnace installation (ash fusion) on the one hand and in the selection of the dust separator for flue gases (degree of dust separation) on the other hand.

In view of the drop in the efficiency rate of the separators after long-continued operation already mentioned, a correspondingly higher value must be specified for the guaranteed efficiency rate when placing the order.

Restriction of Dust Emission for Newly Designed Installations.


Maximum permissible dust emission of new installations in continuous operation c_s as percent of ash introduced
Minimum stack heights
Special authorization above 150 m
Total ash A_m ton/hr introduced in furnaces of the overall installation

References

1. Air Pollution by Smoke from Boiler Installations. Report on the Status of Technology, Comm. Ass. Steam Boiler Owners, Essen, No. 34/35, 1955, p. 455/566.

2. Schäff, K.: Ash Recirculation and Precipitation in Boiler Installations. Ibid, No. 23, 1953, p. 364/74.

3. Münzinger, F.: Steam Power, 3rd Edition, 1949, p. 22, Springer Berlin.

4. Boiler Operation. Review of Practical Experiences. Issued by Comm. Ass. Steam Boiler Owners, 3rd Ed., Essen 1953.

5. Thermodynamic Working Folder. Calculation Data for the Design and Operation of Power Installations. Issued by the Federation of German Power and Heat Engineers, 7th Ed., Düsseldorf 1953/1954 (Cf. Sheets D-16 and D-18.)

6. Andritzky, M.: Dust Precipitation from Smoke and Boiler Operation. Ibid., 1 - No. 23, 1953, pp. 375/84.

7. VDI Specifications No. 2066, Efficiency Tests of Dust Separators, 2nd Ed., Düsseldorf, 1949, New Issue in preparation.

8. Cf. 1, p. 477/84.

9. Diem, M. and R. Trattenberg: Dust Deposition from Smoke Streamers. Ibid., 1- No. 23, p. 391/95.

10. Drimmel, J., H. Fortak. E. Geisler, G. Hollmann, W. Klug, H. Reuter, H. Stumke and F. Wippermann: Laws of Gas Distribution as Basis for Determination of Minimum Stack Height. VDI Research Publication No. 483 (1961). Cf. further:

    Wippermann, F.: Possibilities of a Theoretical Understanding of the Distribution Process. Dust, Vol. 21, No. 2, pp. 104/09.

    Klug, W.: Practical Utilization of Distribution Calculation. Ibid, pp. 109/12.

11. Cf. 1, pp. 504/05.

12. Ibing, R.: Smoke Flow from Stacks in Level Country. VDI Journal, 1954, No. 32, p. 1085.

13. Designation and Significance of the Magnitudes of Refining Furnaces, Ibid., 1- No. 23, pp. 349/315.

14. VGB Specifications for Ordering Dust-Separation Installations for Steam Generators. Ass. Steam Boiler Owners, Essen.

15. Bachmair, A. and K. Schwarz: On the Publication of the First Memoranda of the VDI Committee on Air Purification. Comm. Ass. Steam Boiler Owners, No. 52, 1958, pp. 46/49.

16. Schwarz, K.: On the Regulations on Restriction of the "Emission Specifications" of the VDI Committee on Air Purification. Dust, Vol. 21, 1961, No. 1, p. 6.

VDI CLEAN AIR COMMITTEE SPECIFICATIONS, PUBLISHED IN ENGLISH BY THE DIVISION OF AIR POLLUTION, U.S. PUBLIC HEALTH SERVICE

VDI No.	Title
2090	Sources of Air-Polluting Substances
2091	Restricting Dust Emission From Forced-Draft Boiler Installations, Capacity 10 Ton/Hr and Over, Hard-Coal Fired with Mechanical Grates
2092	Restricting Dust Emission From Forced-Draft Boiler Installations, Capacity 30 Ton/Hr and Over, Hard Coal-Dust Fired with Dry Ash Removal
2093	Restricting Dust Emission From Forced-Draft Boiler Installations, Capacity 30-600 Ton/Hr and Over, Hard Coal-Dust Fired with liquid Ash Removal
2094	Dust Prevention - Cement Industry
2095	Dust Emission From Induced-Draft Ore-Sintering Installations
2098	Restricting Dust Emission From Natural-Draft Steam Generators, Capacity 25 Ton/Hr and Less, Lignite-Fired with Stationary or Mechanical Grates
2099	Restricting Dust Emission in Blast-Furnace Operation
2101	Restricting Dust Emission From Copper-Ore Smelters
2102	Restricting Emission of Dust From Copper-Scrap Smelters
2103	The Restriction of Chlorine Gas Emission
2104	Terminology in Air Purification
2106	Permissible Immission Concentrations of Chlorine Gas
2107	Permissible Immission Concentrations of Hydrogen Sulphide
2108	Permissible Immission Concentrations of Sulfur Dioxide
2109	Restricting Emission of Hydrogen Sulphide and Other Sulphur-Containing Compounds, Except Sulphur Dioxide, From Gas Generators in Coke, Gas, and Coal-Constituent Processing Plants
2110	Restricting Emission of Sulphur Dioxide From Coke Ovens and Gas Plants
2115	Restricting Emission of Dust From Manually Operated Central-Heating Boilers, Capacity 600,000 KCAL/Hr and Less, Fired with Solid Fuels
2281	Restricting the Emission of Fumes From Diesel-Engine Vapors
2284	Restricting Emission of Dust and Sulphur Dioxide in Zinc Smelters
2285	Restricting Dust and Sulphur-Dioxide Emission From Lead Smelters
2290	Restricting Emission From Gas Generators in Coke and Gas Plants
2292	Restriction of Dust Emission in Anthracite-Briquet Factories
2293	Restricting Emission of Dust in Anthracite Process Installations
2302	Restricting Emission of Dust, Tar Mist and Gas when Charging Coke Ovens
2105	Permissible Concentrations of Nitrous Gases